CHAPTER 1

ECONOMICS, SUSTAINABILITY, AND FOREST MANAGEMENT

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Abstract. This chapter provides an overview of the contents of the volume. To put those contents in perspective, it first reviews developments related to the concepts of sustainability and sustainable development, the reactions of some main stream economists, the main problematic features of traditional economics, and the resulting need for a new paradigm within economics if sustainability issues are to be adequately handled. Next, an overview of the economics literature on sustainability and sustainable forest management is provided. Finally, each chapter included in the five parts of this volume is briefly reviewed.

1. INTRODUCTION

The word "sustainable" is not as new to the forestry profession, including forest economists, as it may be to some mainstream economists. The Faustmann Formula, one of the main pillars of conventional forest economics, is based on the idea of a sustained supply of timber for an infinite number of rotations. In the eighteenth and nineteenth centuries several other social scientists expressed their concerns about sustainability of certain products in Britain –for example, Malthus (1798) about food output and Jevons (1865) about coal supplies. However, the recent concerns about sustainability, which were signaled by the publication of 'The Limits to Growth' by Meadows et al. (1972) and 'Our Common Future' by WECD (1987), are not limited to a specific product but include all natural systems and human life. Sustainability concerns have been reinforced by the Rio Earth Summit in 1992 and the

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Johannesburg Summit in 2002. The importance of the concept of sustainability has already been acknowledged by the world community through numerous international conventions such as the Convention for Climate Change, the Biodiversity Convention, and Agenda 21 (Pearce, 1994). Unfortunately, mainstream economists, not all but most of them, have remained one of the most reluctant groups within the scientific community to accept the concept of sustainability as an (economic) issue (Ikerd, 1997); some, specifically Rust Belt economists, feel that sustainability is not an appropriate topic to be discussed by economists (Colander, 2004). In this regard, Dasgupta and Mäler (1994) write:

> ".. most writings on sustainable development start from scratch and some proceed to things hopelessly wrong. It would be difficult to find another field of research endeavor in the social sciences that has displayed such intellectual regress." (Dasgupta & Mäler, 1994, quoted in Beckerman, 1994, p. 192)

Beckerman (1994) follows Dasgupta and Maler:

> " 'sustainable development' has been defined in such a way as to be either morally repugnant or logically redundant. 'Strong' sustainability, overriding all other considerations, is morally unacceptable as well as totally impractical; and 'weak' sustainability, in which compensation is made for resources consumed, offers nothing beyond traditional economic welfare maximization." (Beckerman, 1994, p. 191)

One factor contributing to the prevalence of such observations about sustainability is that traditional, simple economic theory is built on the assumption of a representative "rational economic agent" who is close to being a "social moron" or a "rational fool" in the words of none other than Nobel Laureate Amartya Sen (1977), or a "mindless individual" in the opinion of Hegel (1964, 1967); sustainability cannot be achieved through the choices of "rational fools" or "mindless individuals". Another factor is the discomfort some economists feel with the variety of definitions of sustainability, though this variety does not seem out of context keeping with the fact that economics itself means different things to different people and that there is a broad spectrum of "heterodox" economists, who approach economic issues differently from the so-called main stream "neo-classical" economists.

The intellectual scope of main stream economics has been tragically limited by its working assumption that the world is a simple, homogeneous, and static unit, rather than being full of complexity, diversity, and dynamism. Natural science, specifically physics, has continuously demonstrated, for about the last 100 years, the existence of natural processes and phenomena which do not mesh readily with this world vision of the main stream, while these economists continue to live in the economic equivalent of a Newtonian world. Quantum theory demonstrated that even sub-atomic particles were nothing like the solid objects of classical physics, but instead are abstract entities with a dual aspect. Depending on how we look at them, they appear sometimes as particles and sometimes as waves; in fact, both pictures are needed to give a full account of the atomic reality, and both have to be applied within the limitations set by Heisenberg's Uncertainty Principle. Thus modern physics is governed by the principle of complementarity rather than the principle of substitution. In addition, the isolated material particles are abstractions, their

properties being definable and observable only through their interactions with other systems (Bohr, cited in Capra, 1982, p. 137). Similarly, according to S-matrix theory, also known as the bootstrap approach, nature cannot be reduced to fundamental entities, like fundamental building blocks of matter, but has to be understood entirely through self-consistency – consistent with one another and with themselves (Capra, 1982). This transition from Newtonian physics to modern physics was not easy; even the fathers of modern physics found it difficult to accept.

> " I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair; and when at the end of the discussion I went alone for a walk in the neighboring park, I repeated to myself again and again the question: Can nature possibly be so absurd as it seemed to us in these atomic experiments." …."The violent reaction to the recent development of modern physics can only be understood when one realizes that here the foundations of physics have started moving, and that this notion has caused the feeling that the ground would be cut from science." (Heisenberg, 1963, p. 43)

> "All my attempts to adapt the theoretical foundations of physics to this knowledge failed completely. It was as if the ground has been pulled out from under one, with no firm foundation to be seen anywhere, upon which one could have built." (Einstein, 1949, p.45)

Viewed from this perspective the derogatory remarks about sustainability coming from some well known economists are not surprising. More remarkable, however, is the continuation of their strong belief (implemented in practice) that all preferences of all human beings for all time to come can be adequately captured in a single-modulus discounted utility function even as many experiments, conducted by experimental and behavioral economists, and a common world view provide contrary evidence. These economists continue to base their analysis on the conceptualization of a "rational economic agent", who has only one, and that a static, preference ordering which reflects, as per need, his interests, welfare, actual choices, and behavior (Sen, 1977), and who uses the same preference ordering for all goods, whether public or private, and sources of different types of satisfaction – ethical, spiritual, commercial, and sexual.

The words of "commitment" and "moral" are missing from the vocabulary of the "economically rational agent" but not from the vocabulary of a "human being" or a "socially rational agent". Commitment and morality would involve, in a very real sense, counter-preferential choice, that would destroy the crucial assumption that a chosen alternative must be better than (or at least as good) the other options in terms of the narrowly defined self-interest of the person choosing it; destruction of that assumption renders consumer theory different and much more complex. The traditional narrow approach of mainstream economics on this point does not mean that economists, as a group, are unaware of more realistic preference systems: Harsanyi (1955) proposed a dual structure of preferences—'ethical preferences' and 'subjective preferences', Sen (1973) suggested three categories—Prisoner's Dilemma (PD), Assurance Game (AG), and Other Regarding (AR) – of preferences, and there are many other categories of preferences available in the social choice literature. Similarly, many streams of economics (often termed "heterodox" streams), such as post-Keynesian economics, evolutionary economics, and

ecological economics, along with recent developments in behavioral economics, social choice theory, experimental economics, agent-based modeling, evolutionary game theory, and complexity theory have recognized complexity, multiplicity, dynamism, and inter-connectedness as characteristics of the real world. In fact, an economic agent conceptualized by Kahneman and Tversky (Kahneman and Tversky, 2000), known as K-T man (McFadden, 1999), is close to a "socially-rational agent".

The challenge, therefore, to the current and future generations of economists is to build a new dominant economic paradigm – based on a more organic, holistic, and integrative approach than the reductionist neo-classical paradigm. The now high-profile concept of sustainability offers a challenge to economists to bring the profession closer to the real world. It is now up to the current and next generation of economists to meet this challenge. As Einstein once observed, problems cannot be solved at the same level of thinking that lead to their creation (Ikerd, 1997). Hence, the economic theory of sustainability cannot be based on neo-classical economic theory that is at the root of most sustainability issues, and a new economic theory, rather than a new public policy based on old theory, will be needed to guide humanity toward sustainability or sustainable development.

In simple words, sustainability involves ensuring opportunities for a desirable "quality of life" for all future generations as well as for the present one. It is thus a concept related to the very long-run and, accordingly, one involving considerable uncertainty—"a direction without a precise destination" (Ikerd, 1997). However, the concept of sustainability is quite consistent with the root-word for economics, "oikonomia"—management of the household. Human's quality of life includes not only the economic dimension but at least two others—the ecological and the social. Over the very long-run, human and natural systems cannot be economically viable unless they are also ecologically sound and socially responsible; nor can they be ecologically sound unless they are economically viable and socially responsible; nor can they be socially responsible unless they are also ecologically sound and economically viable (Ikerd, 1997). However, a main pillar of the neo-classical economic theory is the condition of "ceteris paribus" which means that the theory deals with the outcomes of economic activities when "social" and "ecological" conditions are kept constant. The economics of sustainability will have to be based on a different set of principles, in which economic, ecological, and social dimensions are inseparable dimensions of the same organism.

In the efforts of developing economic theory of sustainability, forest ecosystems can be of enormous use due to numerous reasons. First, forest ecosystems are important components of almost all the international agreements related to sustainability – convention for climate change, biodiversity convention, and Agenda 21. Second, interactions between human systems and forest ecosystems can provide an experimental setting to study interactions between ecological, social, and economic dimensions of human welfare. Third, the concept of sustainability, even though in a limited sense (related to timber), has existed for about 150 years in the thinking about forestry, including forest economics. Finally, there have been serious efforts, all around the world, to transform forest management from sustained yield timber management to sustainable forest management. The contributors to this

volume have taken up a challenge to contribute to the development of a new paradigm of the economics of sustainable forest management..

In this volume, leading economists from different streams—behavioral economics, complexity theory, forest resource economics, Post-Keynesian economics, and social choice theory—provide basic foundations for an economics of sustainable forest management. In future there will, we assume, be many other volumes dedicated to these issues, some focused on specific aspects of the economics of SFM. While the main purpose of this chapter is to provide an overview of the contents of the volume, to put those contents in perspective, overviews of the economics literature related to sustainability and sustainable forest management are also included.

2. SUSTAINABILITY AND ECONOMICS

A number of economists, such as Ciriacy-Wantrup (1952), Krutilla (1967), and Ayres and Knesse (1969), had aired their concerns about issues related to sustainability even before the publication of *The Limits to Growth* (Meadows et al., 1972). T*he Limits to Growth* inspired an interest among economists to incorporate natural resources into growth models, and this interest, among some main stream economists but mainly among heterodox economists, has been sustained by the publication of the WECD Report, by the Rio and Johannesburg Summits, and by other similar events. As a result, an enormous volume of literature, from different streams of economics, has emerged on sustainability issues. Some useful sources for the review of this literature are Pezzey (1989, 1992), Pezzey and Toman (2002, 2003), and special volumes of Ecological Economics, September 1997, volume 22, issue 3 and Land Economics, November 1997, volume 73, issue 4. While we are not in a position to summarize this whole literature, we do review some key papers which contributed theoretical foundations for some economic aspects of sustainability.

In 1974, just after the publication of The Limits to Growth, the Review of Economic Studies published a special issue (Volume 41, Issue 128) on The Economics of Exhaustible Resources. Three papers in this volume—Dasgupta and Heal (1974), Stiglitz (1974), and Solow (1974)—provided basic foundations for future debate on the subject. In all three papers, natural resources are assumed to be finite, nonrenewable, essential to production, and (human-made) capital can substitute indefinitely for natural resources. Dasgupta and Heal (1974, 1979) and Stiglitz (1974) use a familiar formulation of an economic problem - the maximization of the present value (PV optimality) of the representative agent's instantaneous utility, using a constant discount rate. Dasgupta and Heal's main finding was that the implications of this PV-maximization approach have grim implications for future generations, as a direct consequence of a positive discount rate and the inherent scarcity of the nonrenewable resources. Stiglitz (1974) assumes the rate of exogenous technical progress to be large enough to offset the effects of resource depletion, and demonstrates the PV-optimal path can have sustained increases in per capita consumption even with a growing population. Solow (1974)

includes Rawl's max-min principle of intergenerational equity in his analysis, and draws two conclusions. First, the max-min criteria seems to be reasonable criterion for intertemporal planning decisions except that it requires a big initial capital stock to support a decent standard of living, and it seems to give foolishly conservative injunctions when there is stationary population and unlimited technical progress. Second, the finite pool of exhaustible resources should be used up optimally according to the general rules that govern the optimal use of reproducible capital; this conclusion depends on the presumption that the elasticity of substitution between natural resources and labor-and-capital goods is no less than unity.

The next contribution in this sequence is commonly known as Hartwick's rule or the Weak Sustainability approach (Hartwick, 1977, 1978a, 1978b). According to Hartwick's rule, in an economy with depletable resources, the rent derived from resource depletion is exactly the level of capital investment that is required to achieve constant consumption over time. Solow (1986) shows that Hartwick's rule is equivalent to maintaining aggregate wealth or appropriately defined stock of capital, including natural resources, at a constant level over time. However, Solow's result assumes a constant interest rate, as pointed out by Svensson (1986) in the same journal, and thus does not actually apply to the economies modeled by Dasgupta and Heal (1974) and Solow (1974)[1]. Later, Asheim (1986) demonstrated that Hartwick's rule cannot be applied to closed economies[2], and in the open economy case, the rule requires resource-rich economies to invest less than their own resource rents, and resource-poor economies to invest more than their own resource rents.[3] Krautkraemer (1985) extended the PV optimality formulation by including resource amenity (resource stock) and consumption in the utility function, and demonstrated that depending on society's discount rate, the initial capital stock, and the nature of the resource amenity, the economy may converge over time to either a low-resource-use equilibrium or a high-resource-use one.

After the publication of Our Common Future (WCED 1987), active discussion of sustainability issues began in the economics literature as well. WECD (1987), however, uses concepts of needs, or lack of compromise or trade off, that cannot be readily included in the framework of conventional economics. Barbier (1987), Pearce (1988), Daly and Cobb (1989), Pearce, Markandya, and Barbier (1989), and Costanza (1991) propelled this debate forward. Pezzey (1989, 1992) and Ahmad, El Serafy, and Lutz (1989) tried to incorporate these within the framework of conventional economics. Daly (1990) highlights three principles of sustainable development: (i) harvest rates should equal regeneration rates (sustained yield); (ii) waste emission rates should equal the natural assimilative capacities of the ecosystems into which the wastes are emitted; and (iii) renewable energy sources should be exploited in a quasi-sustainable manner by limiting their rate of depletion to the rate of creation of substitutes for those renewable resources. This approach is commonly known as Strong Sustainability.

An important contribution in the debate on conventional PV optimization and the sustainability constraint is Pezzy (1997) in which the author defends the possible use of different variants of sustainability as a priory constraint on PV optimality. He argues that such a constraint is not self-contradictory, redundant, or inferior as claimed by Beckerman (1994) and Dasgupta (1995). Pezzey questions Koopman's

(1960) axiomatic foundation, specifically the validity of the stationary axiom of PV maximization that was questioned also by Page (1997). Pezzy proposes an empirical approach that relies on psychological experiments on time preferences to extend the intertemporal welfare function to include a finite value of sustainability in some way. This extension might involve replacing the instantaneous utility function with a more complex function that includes the individual's value of improvements in consumption. An important feature of this approach is that it may result in Pareto-inefficient consumption paths being preferred.

Another common issue in debates on sustainability is the intergenerational distribution of resources. Howarth and Norgaard (1990) was seminal in showing that different endowments of resource rights—a nonrenewable resource stock and labor—across two overlapping generations (OLGs) result in different distributions of wealth, all of them efficient but obviously different in their equity implications, and with no a priori way of judging which is "optimal." Howarth and Norgaard (1992) extend their 1990 model to include many generations, and demonstrate that, even in theory, there is no fixed notion of "correctly" valuing an environmental cost: the value varies with society's view of the future, whether expressed as a discount rate or some sustainability criterion. Several other papers by Howarth (1991a, 1991b) and Howarth and Norgaard (1993) show the full analytical power of the OLG approach to sustainability. Howarth (1995) develops the theme that moral obligations to future generations are distinct from altruistic individualistic preferences for the well-being of future generations, and explores, among other topics, the "precautionary principle." The sustainability literature on intergeneration distribution of resources clearly demonstrates that an adequate treatment of intergenerational equity calls for a framework going well beyond the scope of conventional welfare economics.

Green national accounting is another stream which has attracted many scholars including Repetto (1989), and Pearce and Atkinson (1993). However, as Asheim (1994) and Pezzey (1994) point out, this approach has a common flaw. Shifting an economy from non-sustainability to sustainability changes all its prices. Sustainability prices and sustainability itself are thus related in a circular fashion. Without sustainability prices, we cannot know whether the economy is currently sustainable; but without knowing whether the economy is currently sustainable, currently observed prices tell us nothing definite about sustainability. This theoretical caveat does not imply that green accounting is not useful, but rather that it cannot at this time be carried out in the technically ideal way, and hence requires judgment in the way it is applied.

Unfortunately, the contributions from many other streams of economics such as behavioral economics, complexity theory, and social choice theory, which appear to imply the most serious challenges to the conclusions of neo-classical economics on sustainability issues, have not attracted much attention in the sustainability literature. The over-taking criterion (Atsumi, 1965; von Weizsäcker, 1965), the Suppes-Sen grading principle (Suppes, 1968; Sen, 1970), and the general theory of inter-temporal resource allocation (Radner, 1961; Gale, 1967; Brock, 1970; and McKenzie, 1983, 1986) are highly relevant to sustainability issues, but the social choice literature based on these criteria and principles has not intersected much with

the dominant economic literature on sustainability. Mitra and Wan (1986), using the general theory of inter-temporal resource allocation, addressed the problem of forest management when future utilities are undiscounted, and found that if the utility function is increasing and strictly concave, an optimal solution converges to the maximum sustained yield solution. Chichilnisky (1997) introduces two axioms for sustainable development or sustainable preferences: the first requires that the present should not dictate the outcome in disregard for the future or it requires sensitivity to the welfare of generations in the distant future; and the second requires the welfare criterion should not be dictated by the long-run future or it requires sensitivity to the present. Chichilnisky proves the existence of sustainable preferences[4] and demonstrates that sustainable optima can be quite different from discounted optima, no matter how small is the discount factor[5]. Asheim, Buchholz, and Tungodden (2001) observe that there is a technical literature on inter-generational social preferences including Koopmans (1960), Diamond (1965), Svensson (1980), Epstein (1986), and Lauwers (1997) which essentially presents the finding that complete social preferences that treat an infinite number of generations equally need not admit optimal solutions, and resolves this apparent conflict. Asheim et al. prove that in the framework of ethical social choice theory, sustainability is justified by efficiency and equity as ethical axioms which correspond to the Suppes-Sen grading principle. In technologies that are productive in a certain sense, the set of Suppes-Sen maximal utility paths is shown to equal the set of non-decreasing and efficient paths. Since any such path is sustainable, efficiency and equity can thus be used to deem any unsustainable path as ethically unacceptable. Asheim and Tungodden (2004) propose a new approach, by imposing some conditions on the social preferences, to the problem of resolving distributional conflicts between an infinite and countable number of generations. Pezzey and Toman's (2002) observations about Asheim's work "though the uncompromising rigor of the papers limits their readership to the technical, well-motivated few." are interesting and provide important clues for economist's approach towards sustainability. It seems that economists are looking for simple solutions—maximization of all encompassing discounted utility—for complex problems, unfortunately there are no such solutions for the sustainability dimension of human welfare. A similar unrealism on the part of economists may account for the neglect of complexity theory, behavioral economics, theories of multiple equilibria, evolutionary game theory, and multi-disciplinary approaches in general, and specifically with respect to sustainability questions.

3. SUSTAINABLE FOREST MANAGEMENT AND ECONOMICS

In the last two decades, sustainable forest management (SFM) has emerged as a new paradigm of forest management. This paradigm is in the process of transforming forest management from sustained yield timber management (SYTM) to forest ecosystem management and from forest management by exclusion of user groups to management by inclusion of user groups. The SFM paradigm recognizes three dimensions of human welfare—economic, social, and ecological. In economic terms, the main distinguishing features of SFM are the recognition of diverse and

dynamic preferences of local people (heterogeneous agents), the incorporation of multiple sources of value and utility from the forests (including non-market values), the incorporation of multiple products and services in the production process, inter-generational equity, and a systems approach to forest management. In short, SFM involves a complex matrix of interactions between social, economic and natural systems, and it implies the need for a significant shift in the dominant paradigm of forest economics.

The recognition of distinguishing economic features of SFM brings to the fore the potential conflict between the concept of SFM and the neo-classical economic framework of forest management which has been used for sustained yield timber management (Toman, Mark, & Ashton, 1996). The main response from forest economists to SFM has been the use of direct or indirect valuation techniques for non-marketed "goods" and "services", so that these values can be made comparable with the values of traditional wood products; this, however, is a controversial application of market concepts. The economic literature has already identified numerous problems with the application of these methods for valuation of environmental and forestry attributes. Anther noticeable development has been in the area of multiple criteria decision making, and some examples of this in forestry are Bare and Mendoza, 1992; Gong, 1992; Kangas, 1993; and Liu and Davis, 1995.

Kant (2003a), the first overall review of the forest economics literature from the perspective of economics of SFM, proposed a set of basic principles for the economics of SFM. He argues that the basic idea behind SFM, to manage forests in such a way that the needs of the present are met without compromising the ability of future generations to meet their own needs, demands elements of altruistic and cooperative behavior among social agents in contrast to the self-interest-maximizing rational agent of neo-classical economics. Hence, economic models of SFM should be able to capture both orientations—individualistic as well as altruistic and/or commitment—of an individual's behavior; neo-classical economics, which is guided by the "either-or" principle, is unable to incorporate such dualistic behavior of social agents[6]. Incorporation of such behavior may be possible in economic models that are based on the "both-and" principle that has been accepted by post-Newtonian physicists of the twentieth century. Under the umbrella of the "both-and" principle, Kant (2003a) proposes four sub-principles of SFM economics: existence, relativity, uncertainty, and complementarity.

The 'principle of existence' suggests that we cannot ignore the relevance of situations which have survived for a long time. Hence, we should focus first on achieving an economic understanding of the existing human-forest interactive systems, in order to be able to predict whether the effects of proposed changes would be, on balance, positive or negative. The 'principle of relativity' suggests that optimal solutions are not universal but rather situation specific; in many cases they will involve important non-market forces. The 'principle of uncertainty' suggests that due to uncertainties in natural and social systems, a social agent may typically not be in a position to maximize his outcomes, but will rather search for positive outcomes and learn by experience, such that resource allocation will be improved by adaptive efficiency, whose cumulated effects over time are likely to be more important than the achievement of allocative efficiency at each point of time. The

'principle of complementarity' suggests that human behavior combines both selfish and altruistic elements, that people have both economic and moral values, and that people need forests to satisfy both lower level and higher level needs. Kant (2003a) concludes that the two main additional elements for the economic analysis of SFM are the economics of multiple equilibria and a consumer choice theory that incorporates context-specific and dynamic preferences, heterogeneous agents, and a distinction between needs and wants.

A Special Issue of Forest Policy and Economics (Volume 6, Issues 3-4, 2004) focuses on the economics of sustainable forest management. In this issue, Wang (2004) contrasts SFM with conventional forest management (CFM), and argues that the conventional economic tools cannot be applied satisfactorily to SFM analysis. He proposes an integrative and contextualized knowledge-based two-tier approach for the economics of SFM, in which economic incentives and trade-offs dictate resource allocation and management decisions when sustainable products are involved, but precautionary principles prevail when the integrity of ecosystems is at stake. Kant and Lee (2004) argue that multiple forest values are closer to the concept of 'social states' than market price or monetary value, and the decisions related to SFM are decisions of social choice and not decisions to be guided by conventional benefit-cost analysis, based on the monetization of all costs and benefits. Cardenas (2004), based on the outcomes of economic experiments in rural communities of Colombia, argues that individuals do not seem to follow entirely the conventional economic prediction about externally imposed rules, and people in rural communities can develop norms based on non-enforceable rules of cooperation which may prove as effective as externally imposed rules in SFM. Subhrendu et al. (2004) included heterogeneity of preferences of forest landowners in a regional timber supply model and examined the impact on timber supply in the southern USA. Misra and Kant (2004) suggest an analytical framework for the production analysis of collaborative forest management, and use this framework for the analysis of Joint Forest Management, in Gujarat state of India. Other papers in the issue address various issues related to sustainable forest management such as carbon sequestration, foreign direct investment, and forest valuation.

The economics of sustainable forest management appears to be attracting the interest of a few economists, specifically resource economists, but it has not received the same level of attention from the discipline as has the economics of sustainability in general. Sustainable forest management, the topic of much discussion over the past two decades among a wide range of people involved in the forestry sector—researchers, managers, policy-makers, international agencies, donor agencies, and non-government organizations—has received much less attention from economists. In addition, many economists have not been able to accept the basic differences in economic features between SYTM and SFM, and hence continue to use the traditional but inappropriate economic tools.

The volume starts with chapters on complexity theory, ethics, and sustainable forest management and closes with the basic principles of economics of SFM and new paradigm of economics. In between, three other major themes—consumer choice theory and SFM, social choice theory and SFM, and non-linearities, multiple equilibria and SFM—are highlighted.

4. COMPLEXITY, ETHICS, AND THE ECONOMICS OF SFM

The previous section was designed to give a broad introduction to the economics of SFM. This section draws on the other chapters of the volume to delve deeper into SFM economics. David Colander identifies the economics of SFM as part of a broader trend within economics, that he defines as a switching from the efficiency and control story to the complexity and muddling through story. The efficiency story is about the *state of competition*, is static, and fits well into a calculus framework, while the complexity story is about the *process of competition,* and is a dynamic and evolutionary story. In the complexity story, the invisible hand of the market takes apparent chaos and turns it into an elegantly complex structure that fits together, not perfectly or efficiently, but sustainably. Colander argues that the traditional work in forest economics falls within the efficiency story line. Textbook presentations, like traditional work in forest economics, avoid discussing the fact that efficiency is not an end in itself but rather a means to an end. Sustainability fits much better into the complexity story in which one does not talk about equilibrium; one talks about basins of attractions. Nonlinearities are accepted, and one can expect phase transition jumps as the system evolves. Sustainability means remaining either in the existing basin of attraction or going to a more desirable basin but avoiding less desirable basins.

Colander sees a clear parallel between the shift towards SFM, within thinking about forestry, and the current changes occurring within the economics profession: a change in the allowable assumptions, from the holy trinity of rationality, greed and equilibrium to a broader set which might be called a new holy trinity of purposeful behavior, enlightened self-interest, and sustainability. Acceptance of these changes is apparent in behavioral economics, evolutionary game theory, agent-based modeling, experimental economics, and the new institutional economics. Colander continues his discussion with the outcomes and causes of the changes, and the policy implications of the two stories, concluding with some predictions of how the complexity story will affect future research in SFM.

In the second chapter in this section, M. Ali Khan looks at the economics of SFM through an inter-disciplinary approach involving the ethics of theorizing and modern capital theory. On the basis of his reading of the texts of Kant, Laslett, Bourdieu, Cowen-Parfitt, and Mitra-Wan-Ray-Roy, he locates the general theory of inter-temporal allocation within political scientists' and sociologists' conversations about intergenerational justice. Khan relates Kant's (2003a) four sub-principles of the economics of SFM—existence, relativity, uncertainty, and complementarity to the work of Burke, Hegel, Laslett, Keynes, Marshall, Rawls, and Wittgenstein, noting how they reflect the broad interdisciplinary approach that the subject demands, and put the focus on the principles that go into its theorizing—the "ethics of theorizing", rather than on a particular theory. Next, using the work of Laslett as a guide, Khan situates the vocabulary of inter-temporal ethics and sustainability within that of another conversation being conducted in the space of political theory, a conversation including Laslett's notions of *inter-temporal tricontract* and *intercohort trust,* which he feels go to the heart of the economics of forestry, but which must be used without *hubris,* as a basis for a theoretical opening of a

conversation rather than a closing of it and for a minimizing rather than a maximizing of the distance between the theorist and the theorized.

Khan argues that these larger issues of inter-temporal obligation and submission, when conceived within the relatively narrower frame of economics, specifically forest economics, inevitably revolve around the notions of capital and the rate of discount. Relevant, holistic, conceptions of the former variable include Kant's (2003b) *ecosystem capital and* Bourdieu's (1983) *symbolic capital*. Khan observes that if the words *sustainability* and *inter-temporal equity* are to have any analytical thrust, sustainable policies cannot be rejected, or decided upon, on criteria that have already incorporated in them some form of inter-generational *myopia* or *impatience.* However, even though this idea is simple and well-understood, mainstream economic research has bypassed and ignored it on two grounds: analytical tractability and a commitment to methodological individualism as typified by the analytical construct of the *representative agent.* The current conventional wisdom is to see research incorporating the assumption of a zero time-preference as "dispensable and misdirected", and the effects of this conventional wisdom are pervasive.

From the literature on capital theory and the general theory of inter-temporal resource allocation, Khan draws on the Mitra-Wan (1986) tree farm and the Mitra-Ray-Roy (1991) orchard for a "folk theorem". According to this theorem: "for any dynamic problem falling within the rubric of the theory, there is a threshold discount factor such that the stability properties of the optimal paths are qualitatively the same as those obtained for the undiscounted case for all discount factors above that threshold, and that complicated and rich dynamics, possibly including chaos, obtain for all discount factors below that threshold". Khan identifies the next order of business for both the economics of forestry and that of orchards as the integration of the discounted and undiscounted cases. He sees much merit in an inter-disciplinary approach in which various facets and factors are examined not only in isolation, but also in such a way as to enhance the potential for mutual reinforcement and global insight.

5. CONSUMER CHOICE THEORY AND THE ECONOMICS OF SFM

Second part of the volume addresses the relevance of some recent developments in consumer choice theory to the economics of SFM. Some of the many such developments have already been noted. Here we limit the discussion to the main elements of Post-Keynesian consumer choice theory, some developments from behavioral economics, and theory of discounting.

In his chapter on Post-Keynesian consumer choice theory and the economics of SFM, Marc Lavoie notes that this body of theory reflects a variety of influences (e.g. socio-economists, psychologists, marketing specialists, and individuals such as Herbert Simon and Georgescu-Roegen) whose common point was recognition of the complexity of our world. He identifies four key presuppositions of Post Keynesian economics: epistemology based on realism, ontology based on organicism, rationality being procedural, and a focus on production and growth issues; these

pillars contrast with the symmetric presuppositions of neoclassical theory: instrumentalism, atomism, hyper rationality, and a focus on exchange and optimal resource allocation. The multiplicity of equilibria—the belief that models must be open-ended, is a characteristic feature of post-Keynesian economics, and true uncertainty, historical time, and the importance of aggregate demand help to distinguish it from other heterodox schools.

Lavoie highlights seven principles of post-Keynesian consumer choice theory: the principles of satiation, separability, subordination, growth of needs, and non-independence, procedural rationality, and the heredity principle. A key consequence of these principles, in particular that of subordination, is that the individual's utility index cannot (as in neoclassical theory) be represented by a scalar, but only by a vector, and that the notions of gross substitution and trade-offs—so important in neoclassical economics—are reduced to a secondary role, and operate only within narrow boundaries. The Archimedes principle that "everything has a price" is not part of this theory.

Lavoie notes that ecological economists have used all seven of these principles in their efforts to improve on standard neo-classical consumer choice theory. Such common themes of post-Keynesian economists as the precautionary principle associated with fundamental uncertainty, the heredity principle, weak comparability, incommensurability, and multidimensional choice (similar to the principle of the separability of needs) are emphasized by ecological and forest economists. Both groups entertain the idea of lexicographic choices (tied to the principle of the subordination of needs) in which substitution effects can play no role. The axiom of continuity also ceases to hold under lexicographic preferences, which cancels the validity of the Archimedes axiom that every thing has a price. In reality forest-related preferences are often lexicographic—a substantial proportion of individuals refuse to make trade-offs with material goods when biodiversity, wildlife, or forests are concerned. This has implications for contingency value analyses, based on willingness to pay or willingness to accept compensation, that attempt to take into account the non-market value of ecology or forestry preservation. In sum, Lavoie concludes that post-Keynesian consumer choice theory is highly relevant to forest economics, and could be used as a basis for consumer choice models in the economics of sustainable forest management.

In the second chapter of this part, Chapter 5, Jack Knetsch highlights the relevance of behavioral economics to SFM. Since SFM involves a wider array of uses and benefits from forest land management decisions, this multiplies the need to worry about tradeoffs among them and the associated problems of identification and quantification, and of weighing or valuation. With respect to the valuation of some forest benefits, the findings of behavioral economics provide a more realistic view of people's preferences than does the standard economic theory that forms the basis for most current economic practice and analyses. The often observed differences between behavioral findings and standard theory are, in Knetsch's view, far more than random deviations from an expected outcome; they are, instead, systematic and often large. Some are the result of bounded rationality but many—and those of most interest here—reflect real preferences that are not well modeled by the axioms of standard theory. For example, people often make choices in terms of separate mental

accounts or budgets. And the empirical evidence sharply contradicts the standard equivalence assumption—that the maximum sum people would be willing to pay (WTP) to gain an entitlement is, except for a normally trivial difference due to an income effect, equal to the minimum sum they would be willing to accept (WTA) to give it up. Knetsch suggests that the choice of appropriate measure in such cases depends, among other things, on what people regard as the reference state, and suggests that the appropriate choice of measure may more usefully be determined by "psychological ownership" rather than legal entitlements. Along the same lines, Knetsch observes that people systematically discount the value of future losses at a lower rate than they use to discount the value of future gains. Knetsch concludes that though most economic analyses of resource issues, including those that guide forest management and policy decisions, could be markedly improved by including the insights from behavioral economics, this potential for improvement remains largely unrealized.

In the last chapter of this part, Chapter 6, Colin Price discusses discounting issues, with focus on the plausibility of the tempting (to some people) concept of a declining discount rate (i.e. a discounting procedure whereby the discount rate applied falls the farther into the future is the point of time under consideration). He notes that use of a declining discounting regime does indeed raise the relative attractiveness of slow-growing timber and is also likely to promote environmental interests; but simply lowering the discount rate at all points of time would be even more favorable to such distant future products and benefits, as well as being more defensible from a theoretical point of view. Hence, the declining discount regime requires critical examination.

A basic challenge in deciding on a discounting regime lies in the facts that (a) different people at a given time discount future benefits at different rates and (b) it is not obvious how the benefits accruing to future generations should be discounted. Though observed real interest rates provide some evidence on the discount rates applied by current members of a society (especially the wealthier ones), they do not give us a simple answer on how to discount. A basic complication is that the appropriate discount rate for a given person or group may not be the right one for society as a whole. Against this challenging backdrop, Price first discusses various discounting protocols—for example different intra and inter-generational discounting rates and different discounting rates for different circumstances. Next, he analyses the different aspects of diminishing marginal utility (DMU)—DMU and the basket of goods, DMU and inelastic supply, and DMU and related aggregation scenarios. On this basis of this analysis, he observes: (i) averaging of initial discount rates (across incomes, goods, scenarios) is a crude and inaccurate mode of aggregation; (ii) it is feasible to aggregate the separate discount factors which result from applying different discount rates to different income groups, goods and scenarios, but the resulting composite discount factors correspond to a whole period discount rate which changes through time; (iii) while in most (but not all) cases the whole period discount rate declines through time, the profile may differ according to the underlying reasons for discounting; and (iv) the circumstances which generate the lowest rate of diminishing marginal utility eventually dominate any discount rate derived from aggregate discount factors.

Finally, Price critically examines whether any specific form of discounting can be defended logically; in this respect, he evaluates the compensation argument, the time preference argument, and the diminishing marginal utility argument. In short, discounting for the circumstances of each product, scenario or income group is a time-intensive and controversial task. Using a schedule of discount rates which varies only by time period represents a relatively manageable alternative for project evaluation.

Price concludes that despite the fundamental weaknesses of the declining-rate protocol, governments will be eager to embrace it, because of its superficially plausible intellectual justifications, because it represents a nod in the direction of sustainability, and because in practice it does not change things much. By contrast, the protocol implicitly approved here—giving equivalent present values according to predicted circumstances, not according to the passage of time as such—is demanding procedurally. Perhaps purists should not let the perfect (not discounting at all for the passage of time) be the enemy of the marginal improvement implicit in declining-rate discounting (where benefits accruing in the distant future are less heavily penalized than in present practice). But neither should they let governments —or citizens—settle into a complacent belief that some lowering of the discount rate applied to distant-future benefits constitutes a full and satisfactory solution.

6. SOCIAL CHOICE THEORY AND THE ECONOMICS OF SFM

Our review of the economic literature on sustainability (section 2 above) provided a look at social choice theoretic literature related to the concept of sustainability in general. In Chapter 3, Ali Khan discusses the general theory of optimal resource allocation and reviews the forest management work by Mitra-Wan. This part continues that discussion with two papers with similar motivation.

As discussed in Section 3 above, Mitra and Wan (1986) formulated the problem of forest management as one of optimizing the sum of (undiscounted) utilities from harvests of timber according to the well-known overtaking criterion. In the first chapter of this section, Chapter 7, Tapan Mitra re-examines the foundations of intertemporal preferences which involve intergenerational equity and proposes and provides an axiomatic basis for a social welfare relation (SWR) which is weaker (less restrictive) than that required by the overtaking criterion. The axioms drawn on are Weak Pareto, Anonymity, Completeness and Continuity for finite horizon comparisons, and Independence, but no continuity property on the preference relation in the infinite dimensional space containing the set of consumption streams, a property which characterizes the more restrictive SWR induced by the overtaking criterion.

Mitra applies the new SWR to rank consumption streams generated by the model of forestry used in Mitra and Wan (1986). He calls a consumption stream *maximal* if it is a maximal point in the feasible set in terms of the SWR, and studies properties of maximal paths. Mitra finds that maximal paths converge over time to the forest with the maximum sustained yield, demonstrating that this notion of maximality is enough to provide a theoretical basis for the forest management tradition of

emphasizing maximum sustained yield. In fact, Mitra demonstrates the somewhat surprising result that *all* the qualitative properties of optimally managed forests that one can obtain by applying the more restrictive overtaking criterion can be obtained by applying the weaker and more acceptable SWR he proposes. Mitra, using duality theory, shows that maximal paths have generalized intertemporal profit maximizing (bounded) shadow prices associated with them, just like optimal paths do. Mitra combines the above two findings to establish the result that the set of maximal paths coincides exactly with the set of optimal paths. This leads to a conclusion that in the context of the forestry model, one can completely dispense with the more restrictive overtaking criterion. Mitra notes that, in principle, his analysis can be extended to other forest products than timber.

In the second chapter of this section, Chapter 8, Geir Asheim and Wolfgang Buchholz address a widely debated aspect of sustainability the idea that stocks of natural resources be kept intact, also termed "strong sustainability". Neo-classical economists, with their strong belief in discounted utilitarianism, have rejected this notion of sustainability. Asheim and Buchholz argue that the stock specific sustainability criterion may be defensible not only from instrumental and moral perspectives, but also from a purely economic perspective, when the natural resource cannot be substituted by man-made capital and when further reduction would push the level below the size corresponding to MSY. Heal's work has shown that utility from the resource stock itself and equal treatment of all generation (the Weak Anonymity condition) favor the proposition that optimal paths will involve non-decreasing resource stocks. Asheim and Buchholz extend that work, demonstrating that how stock-specific sustainability constraints can be obtained from rather weak ethical axioms. In particular, the Suppes-Sen grading principle, obtained by combining the Weak Anonymity and Strong Pareto conditions, leads to stock-specific sustainability constraints as long as the resource is renewable or utility is derived directly from the resource stock. Though one must keep in mind that, all models, including the models proposed in this paper, abstract from some important real-world factors, they provide a new thought-provoking economic justification for stock-specific sustainability constraints.

7. NONLINEARITIES, MULTIPLE EQUILIBRIA, AND THE ECONOMICS OF SFM

The possibility of multiple equilibria is a theme running through the volume. The chapters making up the forth part focus specifically on multiple equilibria due to nonlinearities in production processes or management systems.

In the first of these chapters, Barkley Rosser notes that, as forest management comes to incorporate multiple values such as biodiversity, carbon sequestration, and timber it thus comes to involve multiple issues and stakeholders, and many difficult-to-resolve conflicts between groups and goals. Any serious effort to resolve such conflicts ultimately involve the dynamic ecology of forests, including elements such as the role of fire, pest management, and the methods and techniques of cutting trees, especially the patch size of the cuts. Complex dynamics, resulting for example

from different time patterns of the various forest products, services, and management practices can imply multiple equilibria and the possibility of sudden and discontinuous changes in the nature of a forest.

Deep tradeoffs can exist between the local stability of forest ecosystems and their global resilience, tradeoffs that manifest themselves in such contradictions as efforts to prevent forest fires that make forest fires worse, and efforts to eradicate pests that make their attacks worse and more destructive. This idea that in ecosystems there might exist such tradeoffs has become very widespread and influential. Rosser concludes with the observation that the existence of these nonlinearities and the related thresholds and discontinuities complicates policy making in ecologic-economic systems. Policymakers must be especially aware of the interaction among policies and of the threat of system collapse when key thresholds are crossed.

Whereas Rosser focuses on nonlinearities related to dynamics, the paper by Jeffrey Vincent and Matthew Potts looks at the implications of nonlinearities for spatial aspects of forest management, especially in the context of tropical rainforests. They argue that the conservation of biological diversity is one of the most important dimensions of SFM, and that a variety of factors--economic, institutional, and ecological, may cause a nonlinear relationship between the amount of biodiversity conserved in a forest and the amount of timber harvested. Some nonlinearities favor segregated approaches (e.g. some stands dedicated to timber production and others to biodiversity maintenance) while others favor integrated approaches to forest management. Nonlinearities can lead to the counterintuitive result that segregated management may be superior to integrated management even in forest estates comprised of identical stands; the justification for segregated management thus does not hinge only on some forest stands being richer in biodiversity than others. But their analysis also shows that a nonconvex production set does not necessarily imply that segregated management is superior to integrated management, since the relative values of biodiversity and timber also matter. Nonlinearities resulting from species' populations being clumped instead of randomly distributed across the forest favor more integrated management, in the sense of having a large number of small reserves spread across the forest (in the extreme, a refugium within each annual cutting block). Nonlinearties involving species with minimum viable populations favors more segregated management, in the sense of having a small number of large reserves (in the extreme, just a single reserve in one location in the forest).

The diversities and complexities inherently involved in SFM policy-making are reflected in a different way by the general equilibrium model of Joint Forest Management (JFM) presented by Milindo Chakrabarti, Samar Datta, Lance Howe, and Jeffrey Nugent They note that the most optimistic observers see JFM as a creative and potentially optimal property regime combining the separate strengths inherent in property regimes of private ownership, direct state control, and communal property, whose common characteristic across settings is for local communities to receive greater property rights and influence over local natural resources than under the preceding regimes. The experience seems to have varied from place to place, depending on institutional and other characteristics, so the jury is still out on the overall success rate. One approach to a better understanding of

what matters to potential success of JFM is to undertake a modeling exercise, eventually tested through simulation or other empirical verification.

The authors' simple general equilibrium model, which includes five sectors – two community groups, the Forest Department, the government, and a residual sector, incorporates key stylised facts derived from the existing literature. It highlights four important environmental and institutional features of JFM, namely, (i) the heterogeneous character of, and inequality within, forest user groups, (ii) the influence of such heterogeneity on the degree of user group dependence on forest resources, the sustainability of forest production and the degree of inequality between the groups, (iii) the effect of JFM on each of these relationships and considerations, and (iv) the importance of the quality of the forest and the externalities thereof, and the possible effect of JFM on the effectiveness of regulatory control and property rights over forest land. The authors discuss some preliminary possible outcomes on the basis of first order conditions and suggest that it would be useful to conduct simulations for (i) the impact of JFM on forest biomass and forest community's welfare; (ii) a comparison of Pareto optimal conditions to the benchmark case; and (iii) the impact of inequalities on model outcomes. They also suggest several possible extensions of the model.

8. EPILOGUE

In the last chapter, Shashi Kant puts together a brief synthesis of all the ten chapters in the framework of four sub-principles of economics of SFM, and provides an overview of new paradigm of economics, which he terms as Post-Newtonian Economics. He attributes the current status of Newtonian or neoclassical economics to the increasing returns due to information contagion, and establishes direct and indirect correspondences between the different concepts discussed in the ten chapters of this volume and Kant's basic principles of the economics of sustainable forest management. He also identifies the basic differences between the Newtonian and Post-Newtonian economics.

NOTES

[1] In these economies, capital accumulation through never-ending natural resource depletion cause a falling interest rate, and therefore aggregate wealth should rise over time so that the product of the interest rate and aggregate wealth can maintain constant output and consumption (Pezzey & Toman, 2002) .

[2] Asheim divides a closed economy into three classes of people – capital owners, workers, and nonrenewable resource owners, and demonstrates that natural resource owners use a rising resource price to offset their diminishing stocks and achieve constant consumption without any investment. In contrast, interest rate (price faced by capital owners) is falling, and, therefore, this class has to augment its capital stock to maintain constant consumption. Hence, in general, resource-rents in different parts of the economy need to be invested in proportion to ownership of man-made capital, and not in proportion to ownership of natural resource stock.

[3] The more significant of these qualifications is the latter, since if a resource rich economy invests equal to or more than its resource rents its consumption level will rise over time, not the source of concern comparable to that of falling consumption in the resource poor economy which invests equal to or less than its resource rents.

[4] The two axioms imply a more symmetric treatment of generations in the sense that neither the "present" nor the "future" should be favored over the other. The axioms provide internal consistency and ethical clarity, and lead to a complete characterization of sustainable preferences, which are sensitive to the welfare of all generations. The welfare criterion, which these axioms imply, is complete, analytically tractable, and represented by a real valued function. Chichilnisky also proves that many welfare criteria, including the sum of discounted utilities for any discount factor, Ramsey's criterion, the overtaking criterion, Rawlsian rules, and basic needs are not sustainable preferences.

[5] In the case of renewable resources, discounted utilitarian optimum involves a lower long-run stock and a higher long-run level of consumption than the sustainable optimum, and hence it is less conservative.

[6] Some economists may argue that altruistic behavior, moral values, or commitment have been (or can be) incorporated in the conventional economic models by including an appropriate variable in utility function. In such models, however, economic agent remains utility (self) maximizer, and true features of altruism are not captured. A human being, or a socially rational agent, depending on how we look at them, may appear sometimes as selfish and sometimes as altruistic; in fact, both pictures are needed to give a full account of reality, and both have to be applied within the limitations set by the uncertainty of human behavior. Such dualistic nature of human behavior and true uncertainty related to human behavior cannot be captured in conventional economic models, and it will require approach similar to quantum mechanics or S-matrix theory as discussed in the previous section. Similar to quantum theory, such economics will be based on the principle of complementarity rather than the principle of substitution.

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